

Getting Paid for Grid Services and Supply Diversity: Are the Regulators Recognizing These Services?

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ABSTRACT

This paper discusses recent and ongoing regulatory proceedings and the resource modeling they are conducting to support these efforts. These regulatory proceedings could provide additional income streams for geothermal projects or demonstrate the value of geothermal resources in an increasingly decarbonized electric grid. With high penetrations of variable energy resources (VERs) including wind and solar, the North American Electric Reliability Corporation (NERC) became concerned about essential reliability services. These services include frequency response, voltage support and flexible ramping. The Federal Energy Regulatory Commission (FERC) responded to NERC's initial work on essential reliability services by adopting new frequency response reliability standards for balancing areas. FERC also initiated further evaluation of frequency response and voltage support at the generator level to recognize the benefits provided by and potentially, compensate generators capable of providing these services. In response to FERC's adoption of a new reliability standard, the California Independent System Operator (CAISO), is taking steps to procure frequency response services.

In addition to frequency control and voltage support, many countries and sub-nationals are working to create low carbon electric grids that can provide low carbon energy when VERs are not operating. Renewable geothermal energy resources can provide energy during non-solar peak hours and can become key resources for reducing the carbon content of electric grids. Recent modeling in California is showing geothermal energy can provide needed grid balancing services when 50% of the energy serving load must come from qualified renewable energy sources (in California renewable resources exclude hydroelectric resources over 30 MW in size). Recent modeling also shows the addition of geothermal resources provides a significant marginal value for ratepayers of \$75/MWh.

1. Introduction

The power markets in California are changing. Load serving entities in California must provide 33 percent of their energy from qualifying renewable resources by 2020 and 50 percent by 2030.¹ Due to the low cost of solar and wind, most of the load serving entities are buying wind and solar to meet their renewable energy requirements.² Pricing for unsubsidized solar energy is now consistently below \$50 per megawatt-hour (MWh).³ The City of Palo Alto signed a power purchase agreement for \$36.76 per MWh with Hecate Energy for 75,000 MWh per year beginning in 2021 (City of Palo Alto, Utilities Department, Memorandum).⁴ Because of the compensation these facilities receive for renewable energy credits and production tax credits, some solar and wind facilities can participate in the energy market at very low to negative pricing. Most other technologies including geothermal generating facilities cannot continue to operate with energy pricing well below \$50/MWh, let alone negative pricing.⁵

Furthermore and with the exception of local resource adequacy requirements, all energy is treated equally. Geothermal energy facilities employ technology that often includes inertia from the rotation of the steam turbine and governor controls that help stabilize the electric grid through their automatic settings – a load-balancing service the operators require to meet customer demand. These reliability services are currently required of the reliability coordinators through North American Electric Reliability Corporation (NERC) reliability standards such as IRO-001, Reliability Coordination Responsibilities and Authorities. These standards require reliability coordinators to determine specific generator settings and relay settings for generators within their control area. Currently, generators with the traditional capability for meeting these requirements such as spinning equipment must set their equipment to the exact settings specified by the reliability coordinators.⁶ All generators are compensated through the market only for the energy they provide whether or not they provide these additional services. And, in the California Independent System Operator (CAISO) markets, these services are taken for free from resources that provide these services.

How is geothermal energy going to be able to participate in a market when the marginal cost of wind and solar is near zero? How can the other attributes – load-balancing services such as voltage support and frequency control -- of geothermal facilities be valued?⁷ Can all geothermal facilities find a way to turn down during the solar peak? Is there an opportunity for geothermal resources in the CAISO markets? Yes. Energy agencies are finding an all solar energy supply may not be the best operational or economic path for decarbonizing the grid. Why? Because the system operators are starting to see their ability to handle system disturbances decreasing as large rotating equipment from coal and gas fired generation facilities shut down. If geothermal resources can provide these important grid services, the industry needs to understand how to value these services if they are to be paid for them. Furthermore, renewable resources that can operate outside of the solar peak hours become more valuable as the amount of renewable energy on the electric grid approaches 50%. In California, the incremental value of additional solar has been decreasing since 2014 and has little incremental value to the overall system beginning in 2024.⁸

2. Discussion

This paper describes four actions occurring at the Federal Energy Regulatory Commission (FERC) and NERC, and CAISO that may result in additional compensation for voltage support and frequency control. These actions include:

- 1) FERC/NERC
 - a. Reliability Standard BAL-003-1
 - b. Frequency Response NOI
- 2) California Independent System Operator
 - a. CAISO's response to Order No 794
 - b. Implementing California Senate Bill 350

The initial concerns about system stability were raised by NERC, presented to FERC and ultimately, approved by FERC, so this discussion begins with NERC and FERC.⁹

2.1 Federal Energy Regulatory Commission

2.1.1 FERC's Reliability Standard BAL-003-1

NERC's mission is to assure the reliability of the bulk power system in North America.¹⁰ Reliable operation of the grid requires generation and load to be balanced and that frequency remains within predetermined boundaries around 60 Hz in the United States.¹¹ Should the sudden loss of a generator disrupt this balance, it can cause additional generators to trip, under frequency load shedding, or cascading outages.¹² NERC became concerned about the ability of balancing areas to respond to frequency events such as a sudden loss of a major generation resource when a significant portion of the generators are variable energy resources (VERs) consisting of wind and solar resources.¹³ To maintain reliability on the bulk transmission system generation resources need to automatically provide sufficient voltage control, frequency response, and ramping capability.¹⁴ Traditionally, grid operators used these generator services as a condition of interconnection. The large rotating equipment contained sufficient inertia to withstand a drop in frequency in combination with the automatic responses included in the governors. As more and more VERs replace large rotating equipment, the bulk transmission system's ability to respond to

frequency events has declined. NERC's concern was whether the bulk transmission system has sufficient reliability services when VERs did not provide reliability services.¹⁵ Thus, NERC asked FERC to adopt a new reliability standard to be sure each operator of the bulk power system obtained sufficient reliability services. FERC adopted reliability standard BAL-003-1 on January 16, 2014, by issuing Order No. 794 setting the amount of frequency response needed from balancing authorities.¹⁶ This reliability standard requires balancing authorities to demonstrate they have their allocated amount of frequency response capability at all times. The CAISO's response to the new reliability standard is discussed below.

After adopting the new standard, FERC became concerned about whether frequency response capability should be required of all generators interconnected to the grid. FERC is also concerned about the ability of the grid to respond to changes in frequency as more and more baseload, synchronous units with large rotational inertia are replaced with VERs.¹⁷ FERC found that VERs do not contribute inertia unless they are specifically designed to do so.¹⁸

*"In light of the ongoing evolution of the nation's generation resource mix, and other factors, such as NERC's Generator Governor Industry Advisory released in February 2015, the Commission believes that it is prudent to take a proactive approach to better understand the issues related to primary frequency response performance and determine what additional actions beyond Reliability Standard BAL-003-1 may be appropriate."*¹⁹

For example, wind turbines are typically interconnected where the wind turbine rotation is electrically decoupled from the grid so that it does not provide inertia.²⁰ In addition, VERs do not provide primary frequency response without a reservation of capacity or headroom.²¹ If a solar facility is sending maximum output to the grid and the grid suffers a frequency event such as the loss of a generator, the solar facility cannot increase output. In order for the solar facility to provide an increase in output, the facility must be limiting output prior to the frequency event to allow for an increase in generation. FERC's concern is driven by VERs' tendency not to have headroom or primary frequency response capabilities.²² VERs' low marginal cost of production would not allow solar projects to reserve capacity for primary frequency response.²³ The cost to produce additional energy from an existing solar field in operation is almost zero, so the solar operator would want to produce at maximum output to increase revenue. Similarly, a geothermal operator needs to be compensated for the lost generation and the value of the associated renewable energy credits, if the generator is holding back a specified amount of turbine capacity when providing frequency response services. In addition, the rotating steam turbines' inertia needs to be recognized as another valuable part of these frequency response services.

2.1.2 FERC's Frequency Response NOI

In addition to the general lack of ability of VERs to respond to frequency events, a system with less inertia has a faster rate of change in frequency from the loss of a generator and requires an even faster and larger response.²⁴ So, as the coal fleet retires and gas fired generation is turned down or off during solar peak hours, the grid is less able to respond to changes in frequency.

On February 18, 2016, FERC issued a Notice of Inquiry (NOI) looking at whether FERC needs to reform its rules and regulations regarding the provision and compensation for primary frequency response ("Frequency Response NOI").²⁵ FERC is including inertia response, primary frequency response and secondary frequency response within the Frequency Response NOI. Inertial response happens when the rotating masses of online generation and load release or absorb kinetic energy that results from the coupling between the rotating masses and the electric system.²⁶ Frequency response is a measure of the grid's ability to arrest and stabilize frequency deviations.²⁷ Primary frequency response begins within seconds and is provided by automatic and autonomous actions of turbine-governors because the time to arrest frequency deviations ranges from 5 to 15 seconds.²⁸ Secondary frequency response is changes to MW output and usually results from dispatch instructions beginning 30 seconds or more after the disturbance and can take 5 minutes to correct the problem.²⁹

In the NOI, FERC takes notice of the changing energy resource mix resulting in fewer units providing primary frequency response.³⁰ FERC then asks whether all generators should be required to provide such services as a precondition to interconnection at both the large and small generator level through the Large Generator Interconnection Agreement and the Small Generator Interconnection Agreement. FERC also asks whether existing as well as new resources should be required to provide those services.³¹ Initial responses to the Frequency Response NOI run from the MISO Transmission Owners' request that all but nuclear new generators be equipped to provide frequency response³² to the "Competitive Suppliers" request for a market mechanism.³³

FERC's focus on reliability may either create a market for these additional reliability services or require that all existing and new resources, including VERs provide these services as a condition of interconnection. FERC's recognition of the importance of frequency response and voltage support provides an opportunity for resources providing these attributes to receive compensation for these important grid services.

2.2 California Independent System Operator

CAISO^a is working on two initiatives that could provide opportunities to geothermal projects: 1) The first is in response to FERC's new reliability requirements to provide sufficient frequency response services, and 2) the second is the evaluation of whether the larger grid gained by incorporating PacifiCorp as a participating transmission owner with the CAISO helps and/or decreases the cost of reaching California's renewable energy and greenhouse gas reduction goals.

2.2.1 Frequency Response/Inertia

As discussed, FERC's adoption of reliability standard BAL-003-1 set the amount of frequency response needed from balancing authorities.³⁴ Order No 794 set in motion a stakeholder process at the CAISO to address Order 794's requirement for all ISOs to meet frequency-response obligations at all times. CAISO analyzed its ability to meet BAL-003-1. The analysis showed that the increases in VER generation had deteriorated its ability to respond to frequency events from a surplus in 2012 to a deficit of approximately 100 MW/0.1Hz in 2015.³⁵

*"The penetration of non-conventional, asynchronous resources and the subsequent displacement of conventional, synchronous resources with active governor control results in reducing the system inertia levels and frequency responsive headroom respectively due to less kinetic energy provided from non-rotating mass and non-frequency responsive generation online increasing."*³⁶

Thus, CAISO needs to obtain additional frequency-response. CAISO decided to contract for frequency response services from other balancing areas in the short term.³⁷ By selecting this option to purchase frequency services, CAISO has not allowed generating resources or load within the CAISO system the opportunity to obtain additional revenue and provide this necessary grid service. At least two entities objected to CAISO contracting for these services instead of creating a market for frequency response within the CAISO.

*"To prevent undue discrimination, the ISO must either pay all of the resources that are providing the ISO with FR – or pay none of them. A paradigm in which the ISO would take FR service from generators within its Balancing Authority Area without compensation but would provide compensation to the operators of another Balancing Authority for FR service is patently discriminatory."*³⁸

Based upon these comments CAISO plans to begin a second phase of the frequency response process later this year with a plan to evaluate a market product for long-term frequency response in 2017.³⁹ Specifically, CAISO plans to create a market design that procures frequency response performance and allows economic bidding to provide a frequency response product. CAISO did not feel comfortable with creating the new market product including benchmarks for determining compliance prior to FERC's initial deadlines for compliance with BAL-003-1.⁴⁰ CAISO expects to kick off the second phase of the frequency response initiative toward the end of 2016. Geothermal resources could participate in the second phase to create a potential market product for which they could be paid.

2.2.2 Implementing Senate Bill 350

In the second initiative, CAISO is also studying the potential impacts and benefits of becoming a regional transmission entity encompassing multiple states by including the PacifiCorp system as a participating transmission owner in CAISO. This initiative provides two opportunities for geothermal resources through 1) the expansion of the area within which renewable resources can be located and serve the California market, and 2) the demonstration of the benefits provided by geothermal resources. California Senate Bill 350 passed by the California Legislature last year requires that CAISO complete studies and modeling showing benefits to California ratepayers from the expansion in order to proceed.⁴¹ The modeling must include analyses of integration of renewables and emissions of greenhouse gasses.⁴² The study effort is not yet complete. But, June 2016 CAISO model run evaluating the 50% renewable energy requirement in 2030 under the California fully deliverable case the model selected new geothermal resources in Imperial North and South, and Kramer.⁴³ Some of the modeling tools that will inform these regional integration studies include studies for the California Air Resources Board^b, the California Energy Commission (CEC)^c and the California Public Utilities Commission (CPUC)^d to

^aAn independent system operator or ISO is an organization formed at the direction or recommendation of FERC. In the area where an ISO is established, it coordinates, controls and monitors the operation of the electrical power system within a single state but sometimes encompasses multiple states.

^bThe California Air Resources Board is working on a revision to the Scoping Plan that creates the strategy for California's economy wide plan to reduce greenhouse gas. The Scoping Plan proceeding documents can be found [here](#).

^cThe CEC is evaluating the potential renewable energy mix and transmission needed to access these resources in the Renewable Energy Transmission Initiative v2.0 [proceeding](#).

^dThe CPUC is evaluating the value of different renewable resources in the next version of the RPS (renewable portfolio standard) calculator. Information about the RPS Calculator can be found on the CPUC's webpage [here](#).

support a 50% renewable energy requirement by December 31, 2030. The following section reviews the study and modeling results produced for California energy agencies regarding the need to obtain renewable resources other than solar.

This proposed expansion of the CAISO territory could also expand the area from which California load serving entities could procure the most valuable renewable resources under the California renewable portfolio standard (RPS)^e commonly referred to as “Bucket 1” (those resources directly connected to a California balancing authority or with energy dynamically scheduled into California).⁴⁴ California entities are required to obtain set increasing percentages of Bucket 1 resources, those resources that are located in California or directly connect to the CAISO. Although some question the statutory language, an expansion of the CAISO to include PacifiCorp arguably would allow resources connecting to PacifiCorp’s transmission to count as a Bucket 1 resource for California renewable portfolio standard compliance. If such an expansion occurs, geothermal resources outside of California could provide Bucket 1 energy to California load serving entities.

California Senate Bill 350 set a target of 50% of total retail sales of electricity in California must come from RPS sources by December 31, 2030.⁴⁵ Both the CEC and the CPUC now need to create the implementing framework through regulations and decisions. To inform these actions the CEC and CPUC are relying upon electric-system modeling to evaluate reliable and cost-effective solutions to increasing RPS energy from 33% in 2020 to 50% in 2030. California entities procurement of the new renewable generation has been primarily solar and wind due to their competitive price points.⁴⁶ As the amount of solar generation both utility scale and rooftop has increased, the energy agencies and the CAISO have expressed concerns about how the generating profile impacts reliable operation of the electric grid by referring to the “duck curve”.⁴⁷ These energy agencies are now looking at obtaining a more diverse portfolio of renewables with diverse load shapes. In addition, the energy agencies have expressed a need for flexible generation that can turn down during the solar peak hours and increase generation during the afternoon ramp (when solar output decreases and demand increases). Increasing the amount of RPS energy is not their only goal, the CEC and CPUC also need to meet California’s carbon goals of 40% below 1990 levels by 2030.⁴⁸

The twin goals of increasing renewable generation and decreasing the amount of carbon needed to supply energy to the grid creates a demand for geothermal resources. Current modeling is showing the benefits of adding geothermal generation from both a system operation and ratepayer cost perspective as the state approaches the 50% RPS target set in SB 350. The CPUC Energy Division presented a staff paper *Draft 2016 Portfolios for Generation and Transmission Planning* (RPS Calculator v6.2^f) in March of this year taking a look at various renewable portfolio standard sensitivities evaluating in-state and out-of-state resources and technologies.⁴⁹ The draft paper describes the results of three geothermal sensitivities. The sensitivities included Geothermal 1, that reduced the weighted California average geothermal costs by 25% to just below \$5,063 in the model; Geothermal 2, that included 1,664 MW of the highest quality geothermal resources from inside and outside of California preselected and then the model was run; and Geothermal 3, that included both the reduced costs from Geothermal 1 and the 1,664 MW of high quality geothermal resources preselected from Geothermal 2.⁵⁰ The model picked up geothermal resources in the California counties of Imperial, Sonoma and Siskiyou, and in northern Nevada.⁵¹

In addition to the increase in geothermal resources serving California load show in Geothermal 3, Geothermal 3 also shows a reduction in the overall revenue requirement to support a 50% RPS and reduced rate impact even after including the costs from increased transmission to deliver the geothermal resources.⁵² The sensitivity study also shows the lowest overall need for renewable resources (installed MW) and a significant reduction in renewable curtailment under sensitivity run Geothermal 3 (Table 1).⁵³

Table 1. Impact of Different Geothermal Resource Assumptions Compared to Default In-State, Fully Deliverable Portfolio in 2030.

Portfolio	Change in total Generic RPS Resrcs (MW)	Change in Total Tx Upgrades (MW)	Change in PV Ratio (PV GWh / Reb GWh)	Change in Curtail (% RPS Energy)	Change in Revenue Reqmnt (\$MM)	Change in Average Rate (cents/kWh)
Geothermal 1 (cost reduction only)	0	0	0.00	0.0%	-1	0.00
Geothermal 2 (force-in)	-2,710	+4,240	-0.08	-2.5%	+102	+0.08
Geothermal 3 (cost reduction & force-in)	-2,710	+4,240	-0.08	-2.5%	-61	-0.05

^eIn order to qualify as a renewable resource in California the resource must create energy from any of the following: biomass, solar thermal, photovoltaic, wind, geothermal, fuel cells using renewable fuels, small hydroelectric generation of 30 megawatts or less, digester gas, municipal solid waste conversion, landfill gas, ocean wave, ocean thermal, or tidal current. Cal. Publ. Res. Code § 25741(a)(1).

^fThe RPS Calculator is the model used by the Energy Division of the California Public Utilities Commission (CPUC) to develop plausible scenarios for use in the CPUC’s Long-Term Procurement Planning Proceeding (LTPP) and the California Independent System Operator’s (CAISO) Transmission Planning Process (TPP). The model creates plausible portfolios of renewable resources needed to meet RPS policy goals. To build a plausible portfolio, the RPS Calculator iteratively executes an annual procurement simulation in which bundles of renewable resources and transmission upgrades compete with each other to serve CAISO loads in accordance with the RPS requirement for that year. The outcome of each year’s project selection process is based on the relative marginal economic value offered by each bundle of prospective resources and transmission upgrades. CPUC, RPS Calculator Users Guide, Version 6.2, March 2016, p. 1.

Table 1 reproduced from the CPUC Energy Division staff paper *Draft 2016 Portfolios for Generation and Transmission Planning*.⁵⁴

The CEC has kicked off the Renewable Energy Transmission Initiative 2.0[§] (RETI 2.0) process to evaluate transmission options to support reaching 50% RPS by 2030. This planning process includes not only the CEC but also the CPUC, CAISO and California Resources Agency.⁵⁵ The initial analyses are scheduled to be completed later this year. Early analyses presented in May of 2016 are showing the benefits of including geothermal generation in the resource mix.⁵⁶ As more solar photovoltaic (PV) is added to the resource mix, its value declines rapidly after 2014, but the marginal value of Salton Sea geothermal development increases to \$75/MWh which is made up of \$66.2/MWh for energy and ancillary services, \$4.4/MWh for system capacity value and \$2.9/MWh for flexible capacity value (Table 2).⁵⁷

Table 2. The Value of Salton Sea Geothermal Development in California’s Carbon Constrained Future.

<p>Total Savings</p> <p>To arrive at the total savings for adding Salton Sea geothermal to California’s renewable portfolio, we add the three elements below:</p> <ul style="list-style-type: none">– \$66.2/MWh for energy and ancillary service,– \$4.4/MWh for system capacity value,– \$2.9/MWh for flexible capacity value. <p>Thus, we estimate the total marginal value for adding 1,240 MW of geothermal to CA’s 2030 renewable energy mix at \$75/MWh.</p>
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Table 2 reproduced from PowerPoint presentation presented at the Joint Agency Workshop on May 2, 2016, Renewable Energy Transmission Initiative v2.0.⁵⁸

The CAISO has also recently performed modeling of scenarios for transmission planning and SB 350 evaluations of the 50% renewable generation case. When the models are run assuming renewable resources need to come primarily from inside California and need to be deliverable (meaning there is sufficient transmission capacity to deliver the energy to the load at all hours), the model is selecting geothermal resources as part of the mix.⁵⁹ When the model allows low cost Wyoming and New Mexico wind to compete directly with resources located in California, the model picks low cost wind.⁶⁰ CAISO plans to perform additional studies of both in-state and out-of-state portfolios this fall.⁶¹

3. Conclusion: Recognizing the Benefits

The good news for geothermal generation is the growing recognition of its benefits both to system operation and as a balancing mechanism for VERs. The inertia generated by spinning copper in geothermal turbines can provide frequency response and voltage control. In the future these generators may be able to receive compensation for those services. In addition, the problems created by adding renewable generation to the grid without taking into account how that generation can support load over all hours of the day is becoming apparent. And, current modeling results show the high marginal value of geothermal generation that can produce energy outside the solar peak hours and especially, those than can operate flexibly.

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[§]An important part of meeting California’s greenhouse gas reduction goals is moving toward a largely carbon-free electricity system, through energy efficiency, renewable electricity, and increased coordination of supply and demand across the electric grid. Implementing this new mandate with other supply and demand-side program options will require new investments in the state’s electric transmission system. This effort will require planning and coordination across the state and the West. To facilitate electric transmission coordination and planning, the California Energy Commission, California Public Utilities Commission, and the California Independent System Operator have initiated the Renewable Energy Transmission Initiative 2.0, also known as RETI 2.0. RETI 2.0 is an open, transparent, and science-based process that will explore the abundant renewable generation resources in California and throughout the West, consider critical land use and environmental constraints, and identify potential transmission opportunities that could access and integrate renewable energy with the most environmental, economic, and community benefits. Further information about the RETI 2.0 initiative can be found on the California Energy Commission’s website, [RETI 2.0](#).

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7. The Federal Energy Regulatory Commission asked this same question “If generation resources were required to have minimum levels of primary frequency response capability or performance, should such resources be compensated for providing primary frequency response capability, performance, or both? If so, why? If not, why?” 154 FERC ¶ 61,117, United States of America Federal Energy Regulatory Commission, Issued February 18, 2016. [Notice of Inquiry](#), Essential Reliability Services and the Evolving Bulk-Power System – Primary Frequency Response, Docket No. RM16-6-000.
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18. *Id.* p. 8.
19. *Id.* p. 20.
20. *Id.* p. 8.
21. *Id.* p. 9.
22. *Id.* pp. 4 & 8.
23. *Id.* p. 9.
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25. 154 FERC ¶ 61,117, United States of America Federal Energy Regulatory Commission, Issued February 18, 2016. [Notice of Inquiry](#), Essential Reliability Services and the Evolving Bulk-Power System – Primary Frequency Response, Docket No. RM16-6-000.
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